Chapter 10
Lithology of Paleozoic Rock Units in 62 Wells, Anadarko Basin, Oklahoma

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Volume Title Page

By Nicholas J. Gianoutsos, Jaquidon D. Kruger, Philip H. Nelson, and Debra K. Higley

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Compiled by Debra K. Higley

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)

Lithology of Paleozoic Rock Units in 62 Wells, Anadarko Basin, Oklahoma

By Nicholas J. Gianoutsos,[1] Jaquidon D. Kruger,[2] Philip H. Nelson,[1] and Debra K. Higley[1]

Abstract

Lithology derived from mud logs, sample logs, and well logs are presented on eight structural cross sections covering the Oklahoma portion of the Anadarko Basin. Seven lithologies are identified: dolomite, limestone, evaporite, sandstone, red shales/red beds, arkose (locally referred to as granite wash), and shale. All cross sections reveal three major lithologic groups: (1) the carbonate-dominated units of Mississippian age and older, (2) the siliciclastic units of Pennsylvanian age, and (3) the evaporites and red shales of Permian age. In addition to the cross section displays, the lithologic data are provided in spreadsheet form.

Introduction

This report focuses on lithologic determinations of Paleozoic strata in the Anadarko Basin, based primarily on interpretations of mud logs, sample logs, and well logs. It is part of a series of reports that includes (1) chapters by Higley (chapters 6 and 7 of this report) and Gaswirth and Higley (chapter 5 of this report) on the assessment of undiscovered oil and gas resources in the Anadarko basin, and (2) two chapters by Nelson and Gianoutsos (chapters 8 and 9 of this report) that examine the extent and cause of abnormal pressures in the greater Anadarko Basin.

The lithologies reported here were originally interpreted by Gallardo (1989) and Gallardo and Blackwell (1999) for the purpose of computing the temperature structure of the Anadarko Basin of western Oklahoma. Using mud logs, sample logs, and well logs, including spontaneous potential, gamma ray, density, and neutron porosity logs, they assigned 1 of 7 lithologies to each 10-ft interval in 63 wells distributed across the basin. A value of thermal conductivity was then assigned to each lithology, an independent estimate of heat flow was assigned to each well, and the temperature profile was computed for each of the 63 wells, 62 of which are used in the cross sections (pls. 1–8) contained in this chapter of the report.

A significant outcome of Gallardo and Blackwell's work was a map of present-day temperature contours at the top of the Woodford Shale that was compared with a previously published contour map of vitrinite reflectance (Gallardo and Blackwell, 1999, fig. 12). The maps show that the highest vitrinite reflectance (thermal maturity) values and highest present-day temperatures coincide but are offset from the deepest part of the basin. The location of the thermal maturity and temperature maxima was attributed to lateral lithologic variations and their impact on heat conduction (Gallardo and Blackwell, 1999).

The lithologic interpretations used to create the thermal profiles have previously gone unpublished. It is our belief that these gross lithologic interpretations, when viewed at the basin scale, are of sufficient value to warrant their presentation here on a series of structural cross sections showing the lithologic units across the basin, along with selected time stratigraphic boundaries. The 62 wells are arranged in 2 west-east and 6 south-north cross sections (fig. 1, pls. 1–8), providing a basin-scale perspective of lithologic variations.

Procedure

The 62 wells used in this study are the same wells (with one exception) that were used in the thermal study by Gallardo and Blackwell (1999; Appendix 1); that list is repeated here with a few corrections and additions to the well locations and American Petroleum Institute (API) numbers (Appendix 1 of this chapter of the report) compiled from the Oklahoma Corporation Commission online database (2010). The Shell McDaniel 1 well (well number 8, Appendix 1) was not used in the cross sections because the well was not sufficiently deep. Our work flow consisted of preparation of the lithology files for plotting, selection of five time-stratigraphic boundaries for correlation, and the production of the cross-section displays.

[1]U.S. Geological Survey, Denver, Colorado.

[2]Raytheon Company, Dallas, Texas.

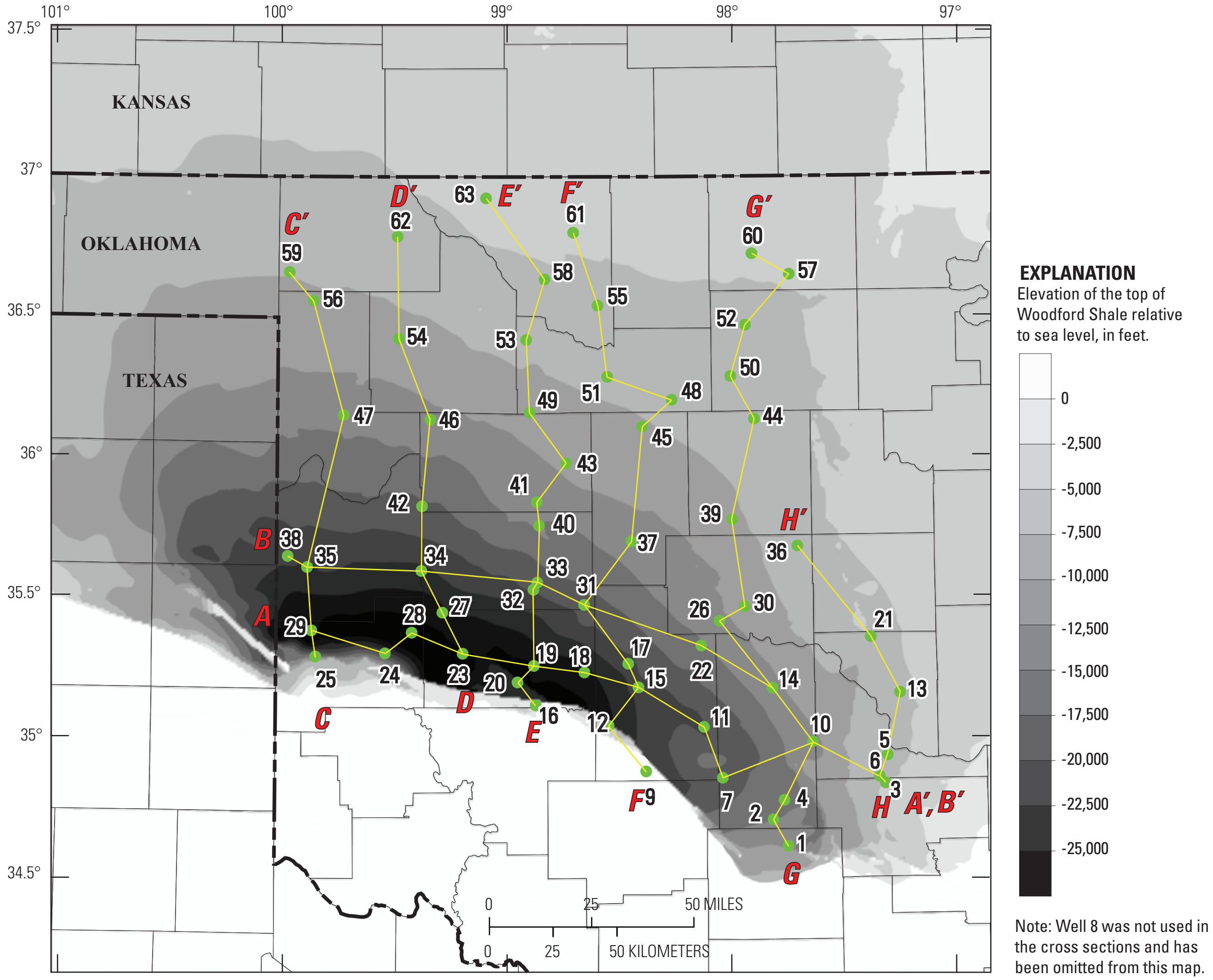

Figure 1. Map of Anadarko Basin and shelf, Oklahoma showing locations of wells and cross sections.

Lithologic Data

Seven lithologies are identified, based on well log response and lithologic information: (1) dolomite, (2) limestone, (3) evaporite, (4) sandstone, (5) red shales (referred to as red beds) (6) arkose (locally referred to as granite wash), and (7) shale. According to Gallardo and Blackwell (1999, p. 339), much of the Permian section is characterized by red shales with interbedded evaporates and other lithologies, commonly on a very fine vertical scale. As these types of deposits are typically referred to as red beds, the term red bed was assigned to all lithologies of Permian age that were not identifiable as another lithology. These seven lithologies are represented by colors on the cross sections shown on plates 1–8.

Lithology was determined for each well on 10-foot (ft) intervals. In older wells from the shelf, sample logs were used in combination with well logs to assign lithologies. In wells from the deep basin, mud logs were the source of direct lithologic information along with the well logs. In cases where a mixed lithology was indicated (for example, dolomitic limestone), the dominant lithology (limestone) was assigned to that 10-ft interval. Siltstone was not included as a category because siltstone could not be reliably interpreted from the available information. The “red bed” lithology was assigned to shales of Permian age whereas the “shale” lithology was assigned to shales (generally gray or black) older than Permian. This distinction, although somewhat arbitrary, was based on the interbedded red shales and evaporites that composed much of the Permian section and had a practical application in terms of the assignment of thermal conductivity values (Gallardo and Blackwell, 1999).

Spreadsheets originally compiled from well logs and other sources were modified to make them suitable as input files for LMKR Geographix plotting software. The spreadsheets gave the thickness but not the depth of each lithology, so the thicknesses were summed to provide a depth for each lithology interface. A single lithology can extend from a minimum of 10 feet to hundreds of feet.

The original requirement for the lithology data was to assign thermal conductivity values from the surface to the base of the Paleozoic section, in order to model temperature in the basin (Gallardo and Blackwell, 1999). To produce continuous lithologies from the top to the bottom of each primary well, information from many primary wells was supplemented with information from nearby wells—lithologies obtained from nearby wells have been retained in this chapter of the report. In addition, where no information was available from either the primary or a nearby well, a lithology was assigned to fill the gap from the top of information to the surface; these lithologies have been deleted from this chapter of the report. Consequently, the lithology data presented in this chapter of the report are based mainly on the information available from each primary well, with supplemental information from nearby wells in many cases.

The lithologic data for each well are tabulated in Appendix 2, including the lithology type, the depth to the top of a given lithology, and the thickness of the lithology units.

Time-Stratigraphic Boundaries

To provide a stratigraphic framework for the lithology logs, five time-stratigraphic units were selected for portrayal on the cross sections: Devonian and older, Mississippian, Lower to Middle Pennsylvanian, Middle to Upper Pennsylvanian, Wolfcampian, and Leonardian to Guadalupian. The boundaries for these five time-stratigraphic units are based approximately on five lithostratigraphically defined tops (fig. 2). Three sources were used to establish the depth of a formation top: (1) mud log picks, which were available for only some of the formation tops; (2) transitions in lithology, which were judged to be definitive for two of the five boundaries (see below); and (3) maps representing stratigraphic units, as determined from mapping software (Dynamic Graphics® Earthvision®). The maps were defined using a database consisting of stratigraphic unit picks from well logs, stratigraphic unit tops from various publications, and a database by IHS Energy (2010). Erroneously high values of a surface were eliminated by visual inspection, followed by spatial filtering to smooth the surfaces.

The five time-stratigraphic boundaries, located approximately using lithostratigraphic correlations (fig. 2), are:

1. Devonian and older. The boundary for the top of the Devonian is based on the top of the Woodford Shale, which is generally of Late Devonian age, although part of the formation appears to be of Early Mississippian age (Kirkland and others, 1992). There is high confidence in the location of the top of the Woodford Shale in most areas, so this boundary is generally shown as a solid line in the cross sections (pls. 1–8).

2. Mississippian. The boundary for the top of the Mississippian is based on the top of the Springer Group, although the uppermost part of the Springer Group is assigned a Pennsylvanian age (Andrews, 2008). Given the uncertainty in the relation between the top of the Mississippian and the top of the Springer Group, this boundary is shown as a dashed line throughout the basin (pls. 1–8).

3. Lower to Middle Pennsylvanian. The boundary for the Middle Pennsylvanian is based on the top of the Cherokee Group of the Desmoinesian Series. As the location of the top of the Cherokee Group was uncertain in many areas, this boundary is shown as a dashed line throughout the basin (pls. 1–8).

4. Middle to Upper Pennsylvanian. The boundary between upper Pennsylvanian and Wolfcampian ages is based on the top of the Wabaunsee Group. In some locations, this boundary was adjusted to coincide with the base of the oldest red shale. Because of the uncertainty in the location of this boundary, it is shown as a dashed line throughout the basin (pls. 1–8).

5. Wolfcampian and Leonardian to Guadalupian. The boundary between Wolfcampian and Guadalupian ages is equivalent to the top of the Chase Group, which was adjusted to the base of the lowermost evaporite. Wherever the thick evaporite is present, confidence in the location of this boundary is high, as represented by the solid line on most of the cross sections.

Cross Section Displays

The structural cross sections (plates 1–8) are designed to be plotted and inspected at a scale of one inch per 2,000 vertical feet; elevations are displayed with respect to sea level rather than to a stratigraphic datum. Spacing between wells is proportional to actual distances. Correlations were not continued across major structural offsets in the southern part of the basin. At the scale of 1 inch to 2,000 ft, the resulting time-stratigraphic boundaries can only be approximated, with uncertainties ranging from a few feet to possibly several hundred feet in a few locations. Thus the results should not be used specifically for detailed correlations in certain cases, as noted on each plate.

Discussion and Summary

All cross sections reveal three major groups of lithologies in the Anadarko Basin: (1) the carbonate-dominated units of Mississippian age and older, (2) the siliciclastic units of Pennsylvanian age, and (3) the evaporites and red beds of Permian age. This association between lithologic groups and three major time-stratigraphic groups persists across the entire state of Oklahoma (Oklahoma City Geologic Society, 1971). These three major lithologic groups play an important role in:

- the thermal regime of the basin (Gallardo and Blackwell, 1999)

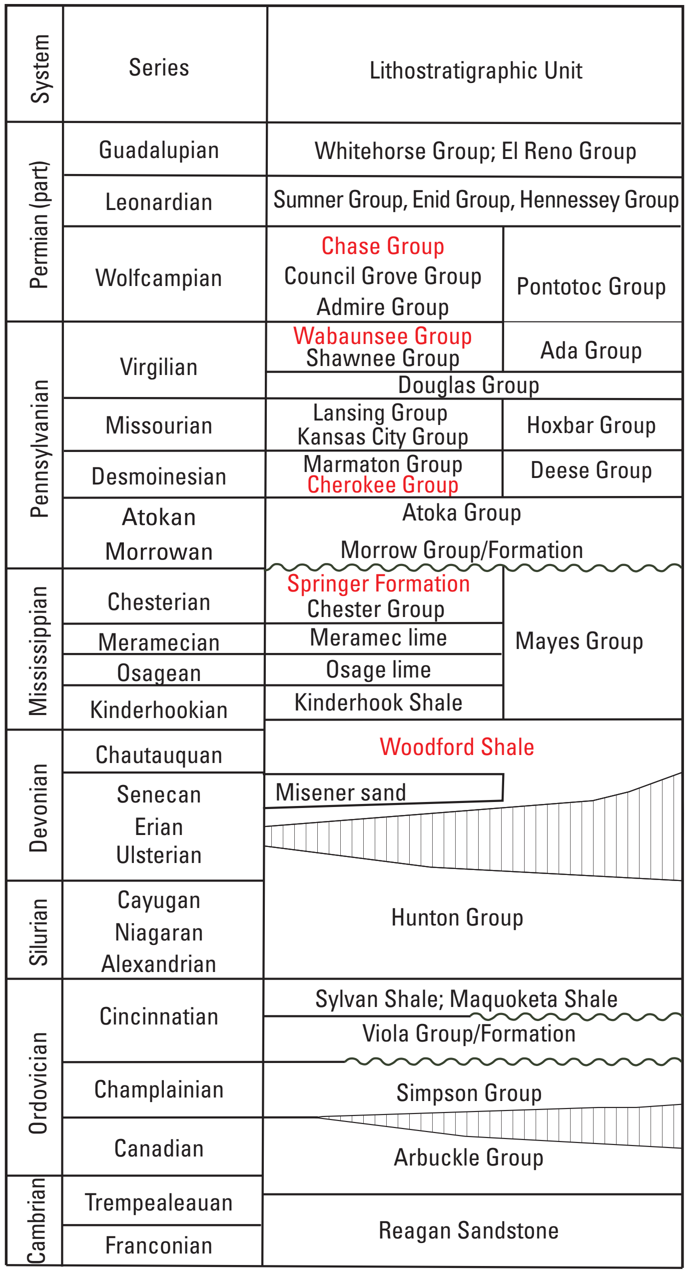

Figure 2. Generalized stratigraphic section for the Anadarko Basin, listing prominent groups and formations, modified from Bebout and others (1993, fig. 5). The cross sections in this report used the tops of 5 horizons (red italicized print) to establish 5 time-stratigraphic boundaries. Granite wash is in the Upper Pennsylvanian and lowermost Permian strata. Red beds and evaporites are generally in rocks of Permian age. [Camb., Cambrian; Miss., Mississippian]

- the hydrologic regime of the basin (Nelson and Gianoutsos, chapter 9 of this report)
- the determination of oil and gas assessment units (Higley, chapters 1, 6 and 7 of this report; Gaswirth and Higley, chapter 5 of this report)
- the migration history of oil and gas within the basin (Higley, chapters 3, 5, 6 and 7 of this report)

In addition to these basin-scale features, other products can be derived from inspection of the plates and manipulation of the data in Appendix 2. For example, cross sections *A–A′* and *B–B′* show that evaporite layers are present in the western part of each cross section but are absent in the eastern part of the cross sections. From the data in Appendix 2, the total thickness of evaporite was computed by summing all 10-ft intervals listed for each well. These sums were used to construct a map showing total evaporite thickness (fig. 3), which shows that the total evaporite thickness exceeds 1,000 ft in western Oklahoma and even exceeds 2,000 ft in three wells in the southwestern part of the Anadarko Basin. Evaporite thickness decreases steadily to the southeast and is absent in the southeastern part of the Anadarko Basin. Other mappable parameters and statistical results can be derived from the lithology data in Appendix 2.

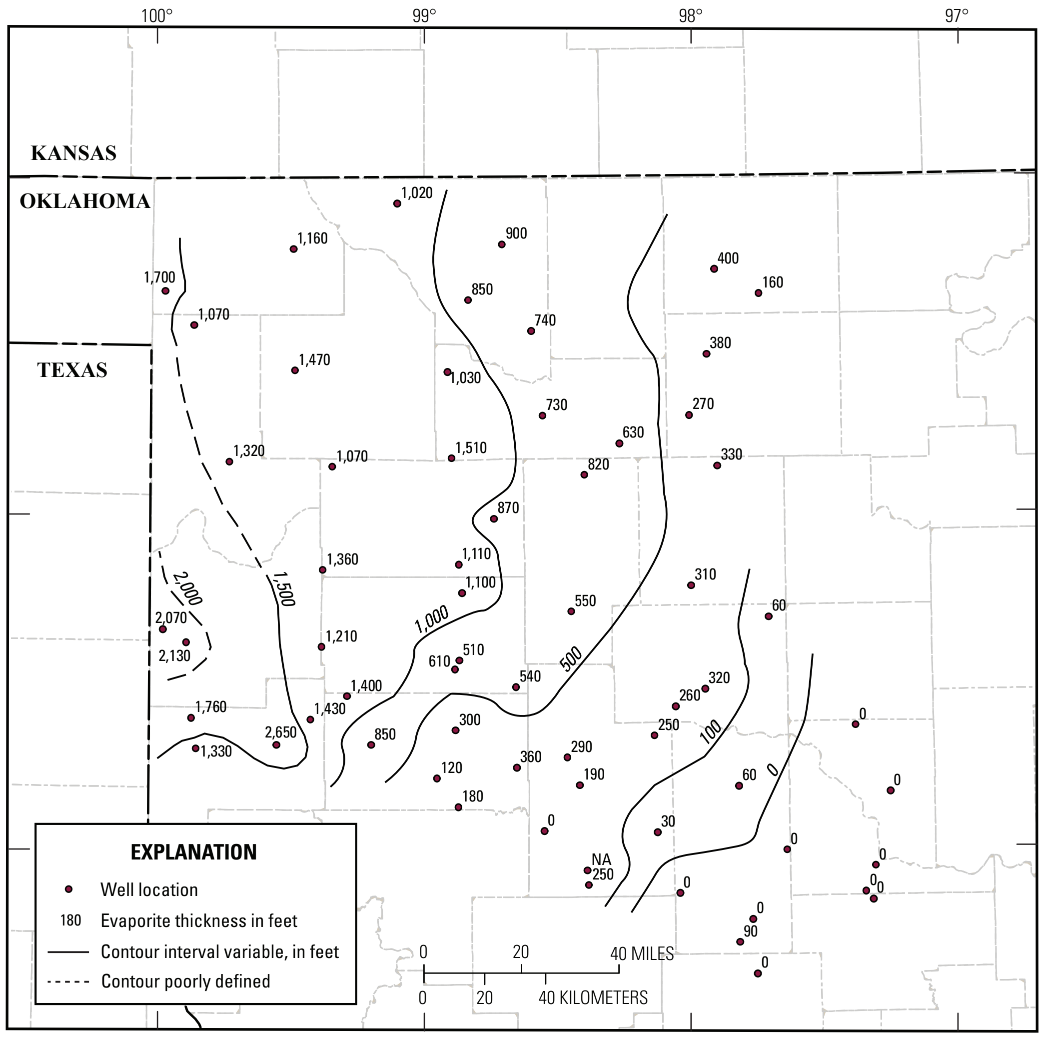

Figure 3. Map of total thickness of evaporite in Permian rocks in the Anadarko Basin.

Acknowledgments

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